Technical Support Document: Toxicology Clandestine Drug Labs: Methamphetamine

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IODINE

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Introduction

The clandestine synthesis of methamphetamine (meth) and other illegal drugs is a growing public health and environmental concern. For every pound of meth synthesized there are six or more pounds of hazardous materials or chemicals produced. These are often left on the premises, dumped down local septic systems, or illegally dumped in backyards, open spaces, in ditches along roadways or down municipal sewer systems. In addition to concerns for peace officer safety and health, there is increasing concern about potential health impacts on the public and on unknowing inhabitants, including children and the elderly, who subsequently occupy dwellings where illegal drug labs have been located.

The Office of Environmental Health Hazard Assessment (OEHHA), in cooperation with the Department of Toxic Substances Control (DTSC), has been charged with assisting in identifying and characterizing chemicals used or produced in the illegal manufacturing of methamphetamine, which pose the greatest potential human health concerns. To address in part this growing environmental problem and the need for public health and safety professionals to make appropriate risk management decisions for the remediation of former methamphetamine laboratory sites, OEHHA has developed two types of chemical-specific information documents.

The first set, technical support documents (TSDs), are referenced, multi-page publications, which contain important health and safety data, exposure limits, and key information for recognizing chemicals used or produced during the manufacturing of methamphetamine. These documents will likely be most helpful to health and safety officers, industrial hygienists, or others interested in more detailed toxicological information. The second set, two-page fact sheets, contain much of the same information as the corresponding TSDs; however, the details are presented in a more succinct, graphical format. The fact sheets will be helpful to individuals, including the public, who want to be able to quickly recognize potential chemicals of concern found in illegal methamphetamine labs in order to avoid inadvertent exposures and resulting health impacts.

For more information or to obtain copies of these and other documents, contact:

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I. Chemical Name

A. IODINE (I_2)

B. Synonyms

Iodine crystals.

II. Role in Clandestine Drug Synthesis: Methamphetamine

Elemental iodine is combined with red phosphorus ("red P") to make hydriodic acid (HI), an essential ingredient in the "HI/red P" method for converting ephedrine to methamphetamine (Turkington, 2000).

III. Chemical Description

A. Appearance

Laboratory grade elemental iodine (I_2) consists of heavy grayish-black to purple crystals that have a metallic luster (ACGIH, 1994). Laboratory grade iodine also may appear as a brown powder (Aldrich, 2001). At room temperature iodine crystals readily volatilize to a violet gas. Iodine gas (vapor) has a highly characteristic, irritating odor (ACGIH, 1994).

B. Taste

Elemental iodine reportedly has a metallic taste (HSDB, 2001).

C. Odor

Strong biting odor (Turkington, 2000); sharp, characteristic, irritating odor (ACGIH, 1994).

D. Odor Threshold

0.8 ppm (8 mg/m^3) (AIHA, 2002).

E. Irritancy Threshold

0.2 ppm (2 mg/m^3) (AIHA, 2002).

F. Odor Safety Class

D; only 10-50% of attentive persons can detect the threshold limit value ceiling concentration (0.1 ppm) in the air (Amoore & Hautala, 1983). *Therefore, odor is not an adequate indicator of the presence of iodine vapor and does not provide reliable warning of hazardous concentrations.*

G. Vapor Density

The vapor density of iodine is 8.8 (air = 1); therefore, iodine vapors are much heavier than air and may tend to accumulate close to the ground or in depressions (AIHA, 2002).

H. Vapor Pressure

0.3 mmHg at 25° C (NIOSH, 1997).

IV. Containers and Packaging

A. Commercial Products

Iodine crystals are available from laboratory supply houses in brown glass bottles. Iodine is also used by veterinarians as a disinfectant for shoeing horses. Iodine may also be obtained by mild heating of any of its salts, e.g., sodium iodide or potassium iodide (Turkington, 2000).

B. Pharmaceutical Solutions of Iodine

Official USP tincture (topical antiseptic) is 2% iodine + 2.4% sodium iodide in 50% ethanol. Strong iodine solution (also called Lugol's solution) is 5% iodine + 10% potassium iodide in water (Hardman et al., 1996). Iodine can be separated from tincture of iodine or strong iodine solution by adding 30% hydrogen peroxide (Turkington, 2000).

V. Chemical Hazards

A. Reactivity

Iodine is an oxidizer and highly reactive (Genium, 1999).

B. Flammability

Iodine is not flammable. However, it is a strong oxidizing agent, and as such, it supports combustion vigorously (Genium, 1999).

C. Chemical Incompatibilities

Incompatibilities include aqueous and gaseous ammonia, powdered aluminum, and active metals such as lithium, barium, sodium, and potassium (Genium, 1999). Iodine is also incompatible with magnesium and zinc (Aldrich, 2001). Violent or explosive reactions can occur when iodine is mixed with acetaldehyde or with acetylene gas (Genium, 1999). Reaction of iodine with liquid chlorine (bleach) is violent. Iodine reacts with ammonia to form nitrogen triiodide, which is highly explosive. Reaction of antimony with iodine produces heat; flame or explosion can result if quantities of the reactants are great enough (HSDB, 2001).

VI. Health Hazards

A. General

Iodine is an essential constituent in the diet and is required for normal function of the thyroid gland. Dietary iodine reaches the circulation in the form of iodide (I^-) (Hardman et al., 1996). Long-term ingestion of iodine in amounts that exceed dietary requirements may lead to iodism (see chronic effects section C). The direct acute toxicity of iodine is due to its irritant properties (NAS, 1980). In excessive amounts, elemental iodine (I_2) is corrosive and irritates tissue via all routes of exposure (inhalation, ingestion, and skin contact). Airborne iodine is an irritant of the respiratory system, eyes, and skin, and may have adverse effects on the central nervous system and cardiovascular system (Genium, 1999). Pharmaceutical solutions applied to the skin or ingested generally have low toxicity. However, in rare instances, an individual may display hypersensitivity to skin contact with iodine. Symptoms of hypersensitivity include fever and generalized skin reaction (Hardman et al., 1996).

B. Acute Effects

Acute toxicity may result from short-term exposure to a high concentration or a large amount. In adults, an average fatal dose of ingested iodine crystals or powder has been estimated to be two to four grams. Ingestion causes burns in the mouth, vomiting, abdominal pain, and diarrhea. Severe intoxication may result in headache, delirium, and a drop in blood pressure. Inhalation causes eye and nose irritation and tightness in the chest. Skin contact causes burns, irritation, and rash (Genium, 1999).

C. Chronic Effects

Repeated ingestion of iodine in amounts that exceed dietary requirements results in a toxic syndrome called iodism. Initial symptoms of iodism are an unpleasant brassy taste, burning of the mouth and throat, and soreness of the teeth and gums. Increased salivation, inflammation of mucous membranes of the nose (rhinitis), eye and mouth, sneezing, laryngitis, bronchitis, and skin rashes are frequently observed (Hardman et al., 1996). Prolonged intake of very large amounts of iodine (approximately ten times the recommended daily dietary allowance) can lead to enlargement of the thyroid, a condition called goiter (NAS, 1980). Studies of the effects of long-term inhalation of iodine vapors by humans are not available. Studies in laboratory animals indicate that long-term inhalation of iodine vapor disrupts thyroid function and reduces the ability of the lungs to take up oxygen. Adverse changes in the lungs of exposed animals include edema, scaling of bronchial epithelium, and bleeding (HSDB, 2001).

D. Skin Contact

Contact with iodine produces irritation and damage. In rare instances, skin contact with iodine produces a sensitization reaction, characterized by generalized skin eruptions and fever. Contact with strong iodine solutions may cause burns (AIHA, 2002). Small amounts of iodine may be absorbed through the skin (NAS, 1980).

E. Eye Contact

Eye contact with saturated iodine vapor causes brown staining of the outermost cell layer of the cornea (the corneal epithelium) followed by spontaneous loss of these cells. However, recovery is usually complete in 2-3 days. Eye contact with 4% iodine solution (tincture) initially produces pain and inflammation, with subsequent loss of the corneal epithelial cells, but recovery from the initial injury is generally complete within a few days. Exposure to iodine vapor at a concentration of 1.6 ppm for just two minutes is sufficient to cause eye irritation. The threshold for eye irritation is reported to be 0.2 ppm (2 mg/m^3), which is significantly below the odor threshold (0.8 ppm, or 9 mg/m^3) (AIHA, 2002).

F. Inhalation

Inhalation of iodine vapor is extremely irritating to the respiratory tract, causing tightness in the chest and sore throat. Iodine vapors increase airflow resistance in the lungs (AIHA, 2002). Inhalation may result in spasm, inflammation, and fluid accumulation (edema) in the voice box, upper airways, and lungs (Aldrich, 2001). Lung edema may be delayed (Genium, 1999). Symptoms may include coughing, wheezing, laryngitis, and shortness of breath (Aldrich, 2001). Some individuals may develop hypersensitivity to inhaled iodine vapor.

G. Ingestion

Ingested iodine reportedly has a metallic taste and stains oral mucous membranes brown (HSDB, 2001). The toxic effects of ingested iodine are primarily due to its corrosive action on the

gastrointestinal tract (Hardman et al., 1996). Ingested iodine may cause vomiting, a drop in blood pressure, headache, and delirium. Food in the stomach inactivates iodine by converting it to iodide (I^-), which is significantly less toxic (HSDB, 2001). Iodine is an essential micronutrient in the diet. The iodine in food is generally present in the form of iodate (IO_3^-), which has a low order of toxicity. Major sources of dietary iodine are iodized salt, bread, milk, marine fish, and seafood (NAS, 1980). The recommended daily dietary allowance for iodine intake by adults is 150 μg/day; slightly higher intakes are recommended for women who are pregnant or lactating, 175 and 200 μg/day, respectively (Hardman et al., 1996).

H. Predisposing Conditions

Pre-existing conditions that have the potential to increase susceptibility to iodine toxicity include diseases of the thyroid, lungs, and kidneys.

I. Special Concerns for Children

Iodides diffuse across the placental barrier and into breast milk. Infant death from respiratory distress secondary to goiter (enlargement of the thyroid) has been reported as a result of mothers taking medications containing iodides (Meditext, 2003). Compared to adults, children have a greater ratio of lung surface area to body weight. Similarly, the ratio of respiratory minute volume to body weight is greater in children than adults. Therefore, at any given concentration of iodine in air, children will probably receive a larger dose than adults will. The vapor density of iodine is much greater than that of air. Therefore, higher concentrations of iodine are likely to be found closer to the ground. Because of their short stature, children may be exposed to higher concentrations of iodine vapor than adults. Children may be more susceptible to the toxic effects of iodine vapor because they are often less likely to leave an area where iodine vapor is present.

VII. First Aid

A. Eyes

Flush eyes with plenty of water for at least fifteen minutes keeping eyes open. Call a physician.

B. Skin

Flush exposed skin with plenty of water for at least fifteen minutes. Remove contaminated clothing and shoes. Call a physician.

C. Ingestion

If the victim is conscious, wash mouth with water. Do not induce vomiting. Seek medical attention.

D. Inhalation

Remove affected person to fresh air. If person is not breathing, give artificial respiration. Give oxygen if breathing is difficult. Obtain medical attention (Aldrich, 2001).

VIII. Standards for Inhalation Exposure

A. Occupational Exposure Limits (NIOSH, 1997; ACGIH, 1994)

1. Ceiling Limit (C) (not to be exceeded at any time): 0.1 ppm (1 mg/m^3)
2. Short-Term Exposure Limit (STEL or ST): Not established.
3. 8-Hour Time Weighted Average (TWA): Not established.
4. 10-Hour Time Weighted Average (TWA): Not established.
5. Immediately Dangerous to Life & Health (IDLH): 2 ppm (21 mg/m^3)

Important Definitions Follow:

Ceiling Limit (C) is a concentration that must not be exceeded during any part of the workday.

Short-Term Exposure Limit (STEL or ST) is a 15-minute time-weighted average concentration that should not be exceeded during any part of the workday.

8-Hour Time Weighted Average (8-hour TWA) concentration is an exposure standard that must not be exceeded during any 8-hour work shift of a 40-hour workweek. 8-Hour TWA exposure standards established by the Occupational Safety and Health Administration (OSHA) are called Permissible Exposure Limits (PELs). 8-Hour TWA exposure standards established by the American Conference of Governmental Industrial Hygienists (ACGIH) are called Threshold Limit Values (TLVs).

10-Hour Time Weighted Average (10-hour TWA) concentration is an exposure standard that must not be exceeded during a 10-hour workday of a 40-hour workweek. 10-Hour TWA exposure standards developed by the National Institute for Occupational Safety and Health (NIOSH) are called Recommended Exposure Limits (RELs).

Immediately Dangerous to Life & Health (IDLH) defines a concentration which poses a threat of death or immediate or delayed permanent health effects, or is likely to prevent escape from such an environment in the event of failure of respiratory protection equipment. IDLH values are developed by the National Institute for Occupational Safety and Health (NIOSH).

"Skin" notation (NIOSH): significant uptake may occur as a result of skin contact. Therefore, appropriate personal protective clothing should be worn to prevent dermal exposure.

B. Emergency Response Planning Guidelines (1 hour or less) (AIHA, 2002)

1. ERPG-1 (protective against mild, transient effects): 0.1 ppm (1 mg/m^3)
2. ERPG-2 (protective against serious adverse effects): 0.5 ppm (5.2 mg/m^3)
3. ERPG-3 (protective against life-threatening effects): 5.0 ppm (52 mg/m^3)

NOTE: There is a significant discrepancy between the IDLH concentration (2 ppm) and the ERPG-3 concentration (5 ppm). Both values are intended to provide an estimate of a life-threatening concentration. Given the lack of human toxicity data for lethality of airborne iodine, OEHHA recommends using the IDLH value as an estimate of a potential lethal concentration.

Emergency Response Planning Guidelines (ERPGs) are developed by the American Industrial Hygiene Association (AIHA) to assist in planning and preparation for catastrophic accidental chemical releases. ERPGs allow emergency response planners to estimate the consequences of large-scale chemical releases on human health, and evaluate the effectiveness of prevention strategies and response capabilities. ERPGs assume that the duration of exposure is one hour or less. They are not intended to be used as limits for routine operations and are not legally enforceable.

Definitions for the three ERPG levels are:

ERPG-1: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

ERPG-2: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

ERPG-3: an estimate of the maximum airborne concentration below which nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

C. Acute Reference Exposure Levels (1-hour exposure) (OEHHA, 1999)

Level protective against mild adverse effects: Not established.

D. Chronic Reference Exposure Level (multiple years) (OEHHA, 2002)

Level protective of adverse health effects: Not established.

Reference Exposure Levels (RELs) are developed by the California EPA's Office of Environmental Health Hazard Assessment (OEHHA). A REL is a concentration at or below which no adverse health effects are anticipated, even in the most sensitive members of the general population (for example, persons with pre-existing respiratory disease). RELs incorporate uncertainty factors to account for information gaps and uncertainties in the toxicological data. Therefore, exceeding a REL does not necessarily indicate an adverse health impact will occur in an exposed population. Acute RELs are based on an assumption that the duration of exposure is one hour or less. Chronic RELs are intended to be protective for individuals exposed continuously over at least a significant fraction of a lifetime (defined as 12 years).

E. Chronic Reference Concentration (lifetime exposure) (IRIS, 2003)

Level protective of adverse health effects: Not established.

IX. Environmental Contamination Concerns

A. Surface Water

Background concentrations of iodine detected in surface waters were reported to range from 4 to 336 μg/l. In aqueous solution, iodine is oxidized to iodate (IO_3^-) and reduced to iodide (I^-) ions. Iodine in drinking water normally contributes a small proportion of total daily iodine intake; the majority of ingested iodine comes from food. Therefore, unless a source of drinking water is highly contaminated with iodine, ingestion of iodine from drinking water is unlikely to cause adverse effects (NAS, 1980).

B. Groundwater

Contamination of groundwater by iodine is unlikely given the rapid conversion of iodine (I_2) to iodide (I^-) in the presence of organic materials. Iodide has a relatively low order of toxicity and is an essential constituent in the human diet.

C. Drinking Water

No information available.

Chronic Suggested No Adverse Response Level (NAS, 1980): 1.2 ppm (1.2 mg/l)

Preliminary Remediation Goal for Tap Water (U.S. EPA, 2002 Region IX): Not established.

D. Soil

In soil, iodine will be oxidized iodate (IO_3^-) and reduced to iodide (I^-) ions, which have a relatively low order of toxicity and are essential micronutrients in the diet.

Preliminary Remediation Goal for Residential Soil (U.S. EPA, 2002 Region IX): Not established.

E. Air

In air, iodine vapor will be hydrolyzed by water vapor to iodate (IO_3^-) and iodide (I^-) ions, which have a relatively low order of toxicity.

Preliminary Remediation Goal for Ambient Air (U.S. EPA, 2002 Region IX): Not established.

F. Indoor Surface Contamination

There are no standards for cleanup of surface iodine contamination. Elemental iodine has a significant vapor pressure at room temperature. Therefore, if present as a contaminant on indoor surfaces, iodine eventually will be depleted through volatilization.

X. Personal Protective Equipment

Wear compatible impervious chemical resistant gloves and clothing and chemical safety goggles. Launder contaminated clothing, and discard contaminated shoes. Wear a supplied air, full face-

piece respirator, air lined hood, or full face-piece self-contained breathing apparatus (SCBA) (Aldrich, 2001).

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